

What is claimed is:

[Claim 1] 1. A manufacturing process for making a surface-mountable printed-circuit board (PCB) module comprising:

etching inner metal layers on both sides of an insulating core to form patterned interconnect on the inner metal layers;
laminating a component metal sheet and a component insulator layer over one of the inner metal layers;
laminating a pad metal sheet and a sacrificial insulator layer over another one of the inner metal layers;
etching the component metal sheet to form patterned component-layer interconnect from the component metal sheet;
etching a pad metal layer of the pad metal sheet to form solder pads from the pad metal sheet;
drilling castellation vias on the pad metal layer, and forming metal inside the castellation vias that connect the pad metal layer to the patterned component-layer interconnect or the patterned interconnect on the inner metal layers;
milling a cavity into the sacrificial insulator layer, the cavity not reaching the patterned interconnect on the inner metal layers; and
wherein the sacrificial insulator layer covered by the solder pads forms a plurality of stand-offs after milling,
whereby the solder pads on the stand-offs are surface-mountable to a main board.

[Claim 2] 2. The manufacturing process of claim 1 further comprising:
milling the sacrificial insulator layer between adjacent solder pads to further form the plurality of stand-offs.

[Claim 3] 3. The manufacturing process of claim 2 wherein drilling castellation vias is performed before etching the pad metal layer to form the solder pads.

[Claim 4] 4. The manufacturing process of claim 2 wherein drilling castellation vias is performed after etching the pad metal layer to form the solder pads.

[Claim 5] 5. The manufacturing process of claim 1 wherein etching the pad metal layer to form solder pads from the pad metal sheet comprises:

plating copper and tin on exposed areas of the pad metal sheet;
removing resist from covered areas of the pad metal sheet;
wherein exposed areas have a tin over copper while covered areas have no tin over the copper;
etching copper from the covered areas but not etching copper from the exposed areas protected by tin; and
removing tin covering copper in the exposed areas to form the solder pads.

[Claim 6] 6. The manufacturing process of claim 1 further comprising:
applying a solder mask to the solder pads with openings over each of the solder pads;
applying solder to the openings in the solder mask to apply solder to the solder pads; and
removing the solder mask.

[Claim 7] 7. The manufacturing process of claim 1 further comprising:
de-panelization by cutting de-panelization lines between adjacent PCB modules on a panel having a plurality of the PCB modules being formed together.

[Claim 8] 8. The manufacturing process of claim 7 wherein the castellation vias are formed along the de-panelization lines, wherein

each castellation via is partly in one of the de-panelization lines and partly on one of the solder pads.

[Claim 9] 9. The manufacturing process of claim 8 further comprising:
finishing the castellation vias during de-panelization by rounding or smoothing edges of the castellation vias.

[Claim 10] 10. The manufacturing process of claim 9 wherein
milling the cavity is performed along with de-panelization on a same machine.

[Claim 11] 11. The manufacturing process of claim 1 wherein
milling the cavity is performed by moving a rotating drill or router bit over the sacrificial insulator layer to cut away a portion of the sacrificial insulator layer.

[Claim 12] 12. The manufacturing process of claim 11 wherein the
sacrificial insulator layer is thicker than the component insulator layer.

[Claim 13] 13. The manufacturing process of claim 11 further
comprising:
drilling inner vias between the inner metal layers and plating the inner vias to form inter-layer interconnect between the inner metal layers.

[Claim 14] 14. The manufacturing process of claim 13 further
comprising:

mounting and soldering components to the patterned component-layer interconnect, wherein the components are integrated circuits and capacitors or resistors.

[Claim 15] 15. The manufacturing process of claim 14 further comprising:

surface-mounting the PCB module to a main board by placing the solder pads over pad metal areas of the main board and heating to solder the solder pads to the pad metal areas.

[Claim 16] 16. A product made by the process of claim 1.

[Claim 17] 17. A printed-circuit board (PCB) module comprising:

multiple metal layers patterned into interconnect traces, each metal layer separated from other metal layers by one or more insulator layers; metalized vias through the one or more insulator layers to form inter-layer interconnect;

a sacrificial insulator layer between a bottom one of the multiple metal layers and a pad-metal layer;

a plurality of stand-offs formed from the sacrificial insulator layer, each of the plurality of stand-offs having a solder pad on an outer surface;

a plurality of castellated vias each connecting a solder pad to one or more of the interconnect traces on one or more of the multiple metal layers; and

a cavity in the sacrificial insulator layer, the cavity formed between the plurality of stand-offs, the cavity having a reduced-thickness portion of the sacrificial insulator layer to prevent exposing any of the interconnect traces on the multiple metal layers.

[Claim 18] 18. The PCB module of claim 17 further comprising:

an integrated circuit component mounted to some of the interconnect traces on a component side opposite a bottom side having the cavity and the solder pads.

[Claim 19] 19. The PCB module of claim 17 wherein the cavity and the plurality of stand-offs are formed by milling away portions of the sacrificial insulator layer.

[Claim 20] 20. The PCB module of claim 19 wherein each of the plurality of castellation vias is an open via on an edge of the PCB module.

[Claim 21] 21. The PCB module of claim 20 wherein the one or more insulator layers comprise epoxy-fiberglass insulator layers.

[Claim 22] 22. The PCB module of claim 21 wherein the cavity is between rows of the solder pads.

[Claim 23] 23. The PCB module of claim 22 wherein each solder pad is on a separate stand-off.